

Effect of Ultra-violet Irradiation of Classrooms on Spread of Measles in Large Rural Central Schools*

Preliminary Report

JAMES E. PERKINS, M.D., F.A.P.H.A.,
ANNE M. BAHLKE, M.D., AND HILDA FREEMAN SILVERMAN

New York State Department of Health, Albany, N. Y.

STUDIES made in the past nine years by William Firth Wells and Mildred Weeks Wells¹⁻⁴ in Philadelphia and its suburbs on the effect of ultra-violet irradiation of classrooms on the spread of measles, chickenpox, and mumps in school children, have suggested that such irradiation has reduced the spread of these diseases, particularly measles, in the classrooms studied. In an attempt to repeat their observations, similar experiments have been undertaken by the New York State Department of Health† in three rural centralized schools in upstate New York.

Actual observations in these experiments did not begin until January, 1945, but the extensive measles epidemic which occurred in New York State in the winter of 1945-1946 makes this early preliminary epidemiological report possible.

The decision to conduct the study in centralized rural schools was determined primarily by their having certain characteristics which constitute highly de-

sirable experimental conditions. Obviously, a decisive demonstration would be most likely if the children under study associated with other children to only a very limited extent outside the environment under observation, in this instance the school environment. Such a situation is approximated in the rural school. In contrast to the experience of the city child, rural children enrolled in a centralized school have most of their contact with one another within the school environment, either in the school building or on the school bus.

Three schools were placed under observation: the Cato-Meridian, Port Byron, and Mexico Central Schools. The State Education Department prepared a list of a number of such schools in accordance with criteria established by us, and these three were chosen from that list because of their similarity and relative proximity to one another. All three were constructed within the past 10 years on the same general architectural plan and have essentially the same ventilating systems (central fans, zoned, capable of delivering 30 cu. ft. of air per minute per child). The floors throughout all three schools are waxed as needed with a commercial floor wax and all three are swept with mops treated with an oily, anti-dust preparation. All three supervising principals

* Presented before the Epidemiology Section of the American Public Health Association at the Seventy-fourth Annual Meeting in Cleveland, Ohio, November 14, 1946.

† This study has been made by a team of the department, with the various aspects represented as follows: epidemiological, Drs. Perkins and Bahlke; statistical, Hilda F. Silverman; engineering, C. R. Cox; and bacteriological, F. W. Gilcreas, assisted by Hazel V. Roberts.

and their boards were sympathetic with the experiment and were willing to give full coöperation. Each of the three schools has a full-time nurse and an adequate system of keeping health records. The pupil populations are comparable socially and economically, and each school has an enrollment of over 600 pupils: 620 in Cato-Meridian, 850 in Port Byron, and 900 in Mexico.

The Cato-Meridian and Port Byron schools are in Cayuga County, and the Mexico school is in adjacent Oswego County. The Cato-Meridian school is situated in a field half way between the villages of Cato and Meridian, which are two miles apart. Cato has a population of approximately 400, and Meridian 300. All the pupils in this school are transported in school buses. The Port Byron school is located in the village of Port Byron, which has about 950 inhabitants, and 80 per cent of the pupils ride to school in buses. The Mexico school is in the village of Mexico where the population numbers 1,350, and 70 per cent of these pupils ride the buses.

The Cato-Meridian school has been fully equipped throughout with ultra-violet lamps except for the gymnasium where there are technical obstacles to such installations. All three schools have at least two sections of each grade, and in Port Byron the room housing one section of each grade through the 8th is irradiated, whereas the room with the other section of each of these grades has no ultra-violet lamps, and thus serves as a control. All places of common congregation within the school (again except for the gymnasium) are irradiated. The Mexico school, with no ultra-violet lamps, serves as a wholly unirradiated control school.

Dr. L. J. Buttolph of the General Electric Company has acted as the consultant lighting engineer in the study. He determined the nature of the original installations and has supervised their

maintenance. Irradiation throughout is by the indirect method with the shielded fixtures suspended about 7 ft. from the floor. The fixtures are of the wall-attached, trough-like type, equipped with an "Alzak" finished aluminum reflector in the shape of a cylindrical parabola. Each fixture is equipped with a 30 watt low pressure mercury vapor germicidal lamp. The total number of fixtures per room varies from one in a few very small rooms to eight in the auditoria and cafeterias. The average classroom has three fixtures, one each on the front and rear walls, and one on the side wall opposite the windows. The hall fixtures are of a double trough type containing two 15 watt tubes per fixture, and are hung from the ceiling in the center of the corridor.

Measurements have been made regularly throughout the study of the radiation output from the lamps in both schools to assure their maintenance at proper operating levels. In general an attempt has been made to maintain an average ultra-violet light intensity of 10-20 milliwatts per sq. ft. throughout the upper air; and 0.2 to 0.5 milliwatts per sq. ft. (or microwatts per sq. cm.) at face level of standing pupils.

It should be noted that despite such vigilance several cases of conjunctivitis, erythema, and desquamation were encountered among the teachers of both schools. So far as could be determined, no pupils were affected. Since most of the faculty stand while teaching, this selectivity can be explained on the basis of a difference of facial levels in the two groups. The symptoms occurred for the most part in fair complexioned individuals and were due to stray radiation from imperfect fixtures or indirect radiation reflected from the highly reflective unpainted plaster ceilings. In every instance the situation was corrected either by applying adhesive tape to a portion of the reflectors or by disconnecting a lamp in the room. Such

measures did not cut the irradiation in the room below what were considered to be adequate levels.

Local arrangements were made with school personnel for periodic checking for burned out tubes, and weekly dusting of the tubes with a clean dry cloth.

Evaluation of results is an involved problem by virtue of the complexities of the environment in which the study is being performed. Such evaluation has been made from analysis of data obtained through several basic procedures which may be outlined briefly as follows:

All absences due to illness in each of the three schools are investigated by the school nurse. Upon notification of a communicable disease in the school population, confirmation of the diagnosis is obtained from the private physician, school physician, or other reliable observer. For the purposes of the present study, the establishment of a diagnosis of measles is followed by an attempt to determine the exact date of onset. The period of infectiousness has been arbitrarily considered to extend from 48 hours before the initial symptoms to 9 days afterward, which in the average case means 5 days before onset of the rash and 5 days afterward. On the basis of these limits it is ascertained which children in the classroom and on the school bus were exposed to the primary case. For the determination of secondary cases the incubation period (that is, from exposure to onset of symptoms) has been arbitrarily set from 7 to 15 days.

In each case an earnest effort is made to determine the source of infection, whether it be in the classroom, on the bus, in the home environment, or elsewhere. In the last circumstance, however, only readily detectable sources are explored, such as extra-school playmates, Sunday school classes, and children's parties.

These historical and epidemiological details are recorded on four separate

forms. Each bus driver maintains a daily record, similar to the teacher's class register, which notes which children rode each of the two daily trips. The school nurse fills out a detailed individual history form for each case with information as to onset of symptoms, clinical characteristics, and contacts. The field epidemiologist and statistician, working with the above information and the class registers, draw up continuous daily records of attendance for each class and each bus from 48 hours prior to the onset of the first case in the specific class or bus to 15 days after the last known infection within the group.

In addition, detailed daily records are kept by the school custodians as to the operation of the ventilating systems, indoor and outdoor temperature variations, relative humidity, and similar information. Furthermore, regular monthly air samples have been obtained for bacteriological analysis from representative classrooms in all three schools, employing both the open plate method and the Wells air centrifuge. These bacteriological data, however, will not be covered in this report.

RESULTS

Overall Morbidity

Since nothing was done to control the spread of infection in the school buses and since there seemed every reason to believe that school buses are as important environments for the spread of measles as classrooms, if not more so, it was not anticipated that there would be any overall reduction in morbidity. If the ultra-violet lamps proved to be of any value in reducing the spread of the infection within the classroom it was felt this would be manifested by changes in the pattern of the cases on a chronological basis rather than in variations in the percentage of susceptible children ultimately developing measles in the irradiated classrooms as compared

TABLE 1
Per cent of Total Cases Occurring in the First Six Grades

School	Enrollment *		Number of Cases		Per cent of Cases
	Total	Kindergarten through Grade 6	Total	Kindergarten through Grade 6	Kindergarten through Grade 6
Cato-Meridian	618	367	144	132	91.7
Port Byron	846	530	220	209	95.0
Mexico	904	492	146	134	91.8
Total	2,368	1,389	510	475	93.1

* Exclusive of children enrolled for less than 30 days.

with the non-irradiated classrooms.

In the course of the outbreak 510 cases occurred among the 2,368 pupils enrolled in the three schools (Table 1). Of the 510 cases, 475, or 93 per cent, occurred among children in the kindergarten and first six grades. Subsequent analyses will be confined to these grades, as the number of cases occurring in each of the higher grades is too small to give statistically significant figures. The analyses are limited to the lower grades also because histories as to a prior attack of measles were less accurate in the upper grades, and because ultraviolet lights were installed only through the 8th grade in the Port Byron school. This limitation was dictated by the fact that beyond the 8th grade the pupils do not remain in one room throughout the school day but circulate from one room to another according to the subject they pursue at a given class hour.

Before considering attack rates, it is

of interest to compare the variation in susceptibility by grade in the three schools, as determined by a history of no prior attack of measles. Table 2 shows that the three schools were roughly comparable as to susceptibility to measles at the start of the epidemic, although Mexico quite consistently had somewhat lower percentages of susceptible children at the various grades.

In Table 3 the percentage of the susceptible children who developed measles is indicated for each grade in each school. It will be noted that there is no consistent difference between the three schools, with 78 per cent, 84 per cent, and 69 per cent, respectively, of the children in these grades of the Cato-Meridian, Port Byron, and Mexico schools developing the disease.

This lack of significant variation in total attack rates in the irradiated and non-irradiated classrooms may be indicated further by splitting the Port

TABLE 2
Per cent of Pupils Susceptible to Measles as of Start of Epidemic *

Grade	Enrollment			Susceptibles			Per cent of Total		
	Cato-Meridian	Port Byron	Mexico	Cato-Meridian	Port Byron	Mexico	Cato-Meridian	Port Byron	Mexico
Kg.	54	70	55	45	57	33	83.3	81.4	60.0
1	42	85	85	20	58	54	47.6	68.2	63.5
2	58	81	74	32	42	34	55.2	51.9	45.9
3	61	74	72	30	35	25	49.2	47.3	34.7
4	55	76	72	19	27	19	34.5	35.5	26.4
5	51	83	58	12	19	14	23.5	22.9	24.1
6	46	61	76	12	11	14	26.1	18.0	18.4
Total	367	530	492	170	249	193	46.3	47.0	39.2

* Start of epidemic here means start of epidemic in each grade. Children who entered after start of epidemic are classified according to status they had at time of entrance.

TABLE 3
Per cent of Susceptible Children Who Developed Measles, by Grade

Grade	Susceptibles			Measles Cases			Cases per 100 Susceptibles		
	Cato-Meridian	Port Byron	Mexico	Cato-Meridian	Port Byron	Mexico	Cato-Meridian	Port Byron	Mexico
Kg.	45	57	33	39	57	30	86.7	100.0	90.9
1	20	58	54	15	53	43	75.0	91.4	79.6
2	33 *	42	34	24	35	27	72.7	83.3	79.4
3	30	35	25	24	27	15	80.0	77.1	60.0
4	19	34	19	15	20	11	78.9	58.8	57.9
5	12	25	14	7	14	4	58.3	56.0	28.6
6	12	11	14	8	8	4	75.0	72.7	28.6
Total	170	249 †	193	132	209 ‡	134	77.6	83.9	69.4

* One child exposed in both classrooms of this grade.

† Thirteen children not included in this total were exposed in two classrooms and are counted in both.

‡ Five children not included in this total were exposed in two classrooms and are counted in both.

Byron grades into irradiated and non-irradiated sections (Table 4). Because of the small numbers, rather marked fluctuations in percentages occur but it is evident that there is no significant difference in the attack rate among susceptible children in the irradiated rooms compared with those non-irradiated. Combining the first six grades for each section 82 per cent of the susceptibles in the unirradiated sections acquired measles compared with 86 per cent of those in the irradiated sections.

At this point one might consider the desirability of a more refined analysis in the calculation of measles attack rates, taking into consideration not only the susceptible children in individual classrooms but the volume of air and

the air change. Such a complex analysis is hardly indicated, however, in view of the apparent uniformity of ventilation in the various classrooms, the essential uniformity in the number of susceptibles per room for a given grade, and the uniform size of the classrooms. Of the 43 rooms represented in the first six grades of the three schools, the range in cubic content varies from only 7,400 to 8,700 cu. ft. in 40 of them. Twenty-five of these 40 rooms, in fact, are exactly the same size (8,448 cu. ft.). The remaining three rooms are of the following capacity: 6,870 cu. ft. (Kindergarten B in Mexico); 11,352 cu. ft. (Kindergarten A in Port Byron); 11,880 cu. ft. (Kindergarten B in Cato-Meridian).

TABLE 4

Port Byron School: Per cent of Susceptible Children Who Developed Measles in Irradiated Rooms Compared with Those in Unirradiated Rooms

Grade	Susceptibles		Measles Cases		Cases per 100 Susceptibles	
	Unirradiated	Irradiated	Unirradiated	Irradiated	Unirradiated	Irradiated
Kg.	29	28	29	28	100.0	100.0
1	19	39	18	35	94.7	89.7
2	22	20	18	17	81.8	85.0
3	16	19	11	16	68.8	84.2
4	14	20	8	12	57.1	60.0
5	12	13	7	7	58.3	53.8
6	9	2	7	1	77.8	50.0
Total	119 *	130 †	97 ‡	112 **	81.5	86.2

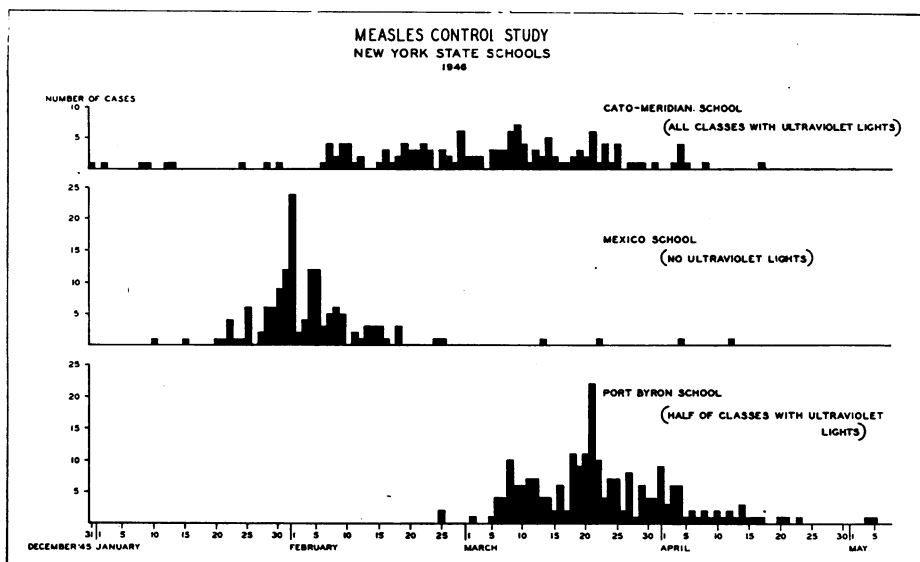
* Two children not included in this total were exposed in two classrooms and are counted in both.

† Eleven children not included in this total were exposed in two classrooms and are counted in both.

‡ One child not included in this total was exposed in two classrooms and is counted in both.

** Four children not included in this total were exposed in two classrooms and are counted in both.

CHART 1



Chronological Pattern

When one looks at the pattern formed in each school by cases by date of onset a definite difference is noted in the three patterns, as shown in Chart 1. From this chart it is immediately evident that the Cato-Meridian school experienced an extended outbreak with cases dribbling along from December 31, 1945, to April 17, 1946. In contrast, the Mexico school experienced a sharply explosive outbreak about the first of February. Between these two patterns lies the pattern for Port Byron with an outbreak less explosive than that in Mexico but not so protracted as that experienced in Cato-Meridian.

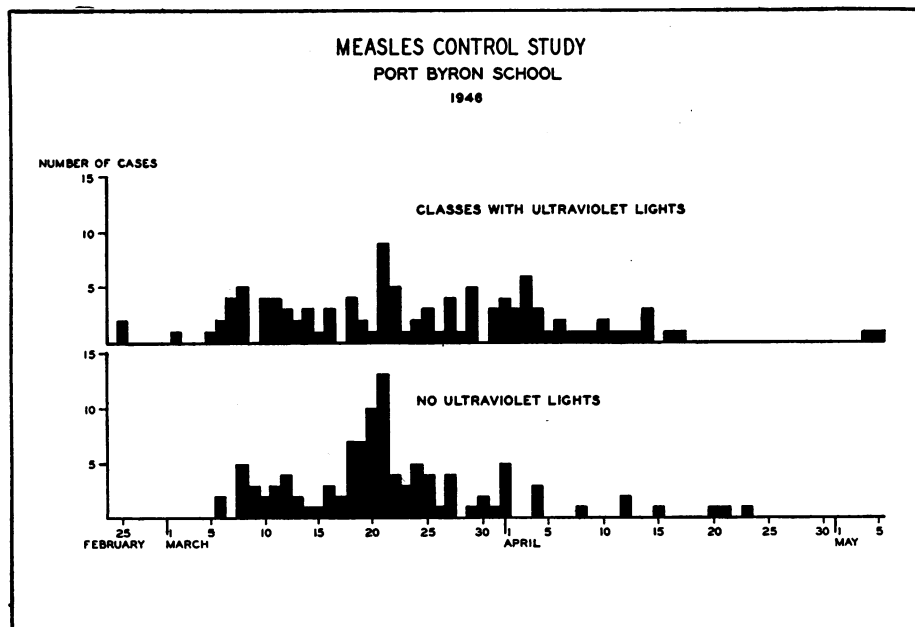
These variations in pattern correspond to the relative degree of irradiation of the three schools, since Cato-Meridian school was completely equipped with lights, Mexico school had none, and in the Port Byron school half of the sections of the lower eight grades were irradiated while the corresponding halves of the same grades were not.

In an attempt to determine whether these variations in pattern are actually

due to the ultra-violet lights a number of analyses were made. If one separates the cases in the Port Byron school according to whether they occurred among children in irradiated or non-irradiated classrooms, another distinct difference in patterns results, as shown in Chart 2. It is evident from this chart that the cases occurring in classes with ultra-violet lights were spread out over a longer period of time than the cases which occurred in the classrooms without ultra-violet lights. Since these classes otherwise apparently were comparable, it is difficult to ascribe these differences in pattern to anything other than to the presence or absence of the lights.

The variations in explosiveness of cases in the irradiated classrooms versus non-irradiated classrooms may be measured by calculating the interval in days covered by the dates of onset for the middle 80 per cent of the total number of cases; that is, 40 per cent of the cases above and 40 per cent below the median case. For the combined grades, the intervals for the unirradiated

CHART 2

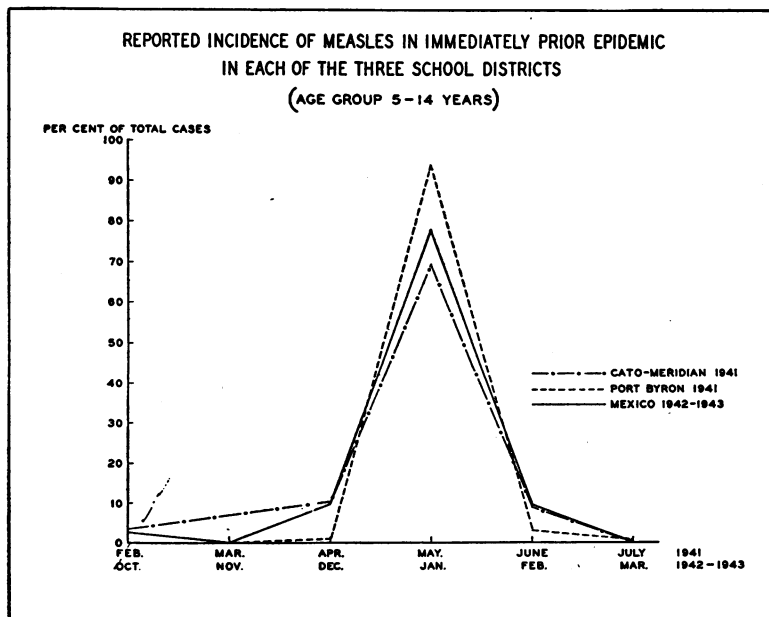


classrooms in the Mexico and Port Byron schools were 15 and 17 days respectively, and for the irradiated classrooms in Port Byron and Cato-Meridian

schools, the intervals were 24 and 26 days, respectively.

Returning to a consideration of the contrast between the protracted smoul-

- CHART 3



dering outbreak in the Cato-Meridian school and the patterns for the Mexico and Port Byron schools, it would be pertinent to determine what variation in pattern occurred in these three schools in the last previous outbreak of measles in each. Unfortunately, the school health records are such that it is impossible to settle this point from them. However, it is possible to estimate the picture from reports received in the State Department of Health of cases in the 5 to 14 year age group for the townships served by these school districts for the year in which the last previous measles epidemic occurred (1941 for Cato-Meridian and Port Byron school districts, and 1942-1943 for the Mexico school district).

Such cases of measles reported by months in these years would necessarily seem to reflect the pattern in the schools themselves. The patterns of total cases are indicated in Chart 3. From the per cent of total cases reported in each month it will be noted that the outbreaks were very explosive in all three school districts, in marked contrast with the variations in patterns for the three schools in 1946.

School Rooms Versus Buses in the Spread of Measles

It may be assumed that the differences in the chronological pattern of measles incidence in the three experimental schools were due, in part at least, to the presence or absence of ultra-violet irradiation in the classrooms of those schools. If the school buses were an important factor in the spread

of the disease and contributed significantly to the equalization of the total attack rates, the data should show this.

Any attempt to analyze the data in relation to bus operation is made difficult through numerous uncontrollable factors. The most obvious of these, the fact that practices with regard to bus operation vary markedly from school to school, makes comparisons between the three schools hazardous, and doubtless other variables are equally important. However, all such factors would seem to be unimportant as they relate to the children in one particular school. Thus it is possible to make what should be valid comparisons between attack rates in children in irradiated and un-irradiated classrooms of the Port Byron school according to whether they did or did not ride buses. These rates for the kindergarten and first six grades are presented in Table 5.

It will be noted that the attack rates among the bus-riding and non-bus-riding susceptibles in unirradiated classrooms was essentially the same, 83 per cent and 77 per cent respectively. In contrast to this the attack rate of 90 per cent in bus-riding susceptibles of the same grades in irradiated classrooms is significantly greater than that of 69 per cent among the irradiated non-bus riders. The school bus, therefore, did appear to play a somewhat greater role in the dissemination of measles among children in irradiated classrooms than among those not irradiated.

The relatively high attack rate of 69 per cent among non-bus riders attending irradiated classrooms is interesting,

TABLE 5

Measles Attack Rates among Bus Riders and Non-bus Riders of Port Byron School Kindergarten through Sixth Grades

	Unirradiated Classrooms			Irradiated Classrooms		
	Susceptibles	Cases	Attack Rate per 100	Susceptibles	Cases	Attack Rate per 100
Bus riders	88	73	83.0	104	94	90.4
Non-bus riders	31	24	77.4	26	18	69.2

but not surprising when note is made of the fact that these were children living in the village. Presumably they had greater opportunity for extra-school contact with other children than bus riders who live for the most part on outlying farms, and this extra-school contact could have been an important contributory factor to the incidence in this non-riding irradiated group.

CONCLUSIONS

These analyses of the occurrence of measles in three centralized rural schools seem to indicate that ultra-violet lights in the classrooms did modify the spread of measles in those classrooms. It is not to be construed, however, that upon the basis of these findings, the authors are recommending routine installation of ultra-violet lamps in classrooms.

Further experimental investigation is needed, and the department intends to

continue its studies, observing the effects on other communicable diseases, particularly chickenpox and mumps. In accordance with original plans, the study is to be modified by the installation of triethylene glycol vaporizers in the school buses.

ACKNOWLEDGMENTS—The excellent coöperation of the entire school personnel of all three schools and the facilities of the Syracuse Department of Health Bureau of Laboratories under the direction of Dr. O. D. Chapman are gratefully acknowledged.

REFERENCES

1. Wells, W. F., Wells, M. W., and Wilder, T. S. The Environmental Control of Epidemic Contagion. I. An Epidemiological Study of Radiant Disinfection of Air in Day Schools. *Am. J. Hyg.*, 35:97 (Jan.), 1942.
2. Wells, W. F., and Wells, M. W. Dynamics of Air-Borne Infection. *Am. J. M. Sc.*, 206:11 (July), 1943.
3. Wells, W. F. Air Disinfection in Day Schools. *A.J.P.H.*, 33:1436 (Dec.), 1943.
4. Wells, Mildred Weeks. Ventilation in the Spread of Chickenpox and Measles Within School Rooms. *J.A.M.A.*, 129:197 (Sept. 15), 1945.

Purchase of Federal Surplus Property

The National Institute of Governmental Purchasing (730 Jackson Place, N.W., Washington, D. C.) calls attention to the abandonment of priorities in purchasing federal surplus property that is threatened by the recent decontrol of prices. It has sent an official statement of policy to every member of Congress and other public officials and businessmen in which it deplores the

hardships already put in the way of state and local governments in their attempts to buy surplus properties. Price decontrols increase these hardships. The statement calls upon the Surplus Property Administrator to appoint an advisory committee of state and local purchasing officials to plan a constructive program for making surplus available to tax supported agencies.